

1996
Executive Research Project

Information Age Partnership
DoD Airwaves and the Microchip

Joseph E. Sulick
Department of Air Force
Civilian

Faculty Research Advisor
Captain Gary Crahan, USN



19961002 010

DFIC QUALITY INSPECTED 3

The Industrial College of the Armed Forces
National Defense University
Fort McNair, Washington, D.C. 20319-5062

DISTRIBUTION STATEMENT 4

Approved for public release;
Distribution Unlimited

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED		1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY N/A		3. DISTRIBUTION/AVAILABILITY OF REPORT Distribution Statement A: Approved for Public Release: distribution is unlimited.	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A			
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NDU-ICAF-96-		5. MONITORING ORGANIZATION REPORT NUMBER(S) N/A	
6a. NAME OF PERFORMING ORGANIZATION Industrial College of the Armed Forces		6b. OFFICE SYMBOL (If applicable) ICAF-FA	
7a. NAME OF MONITORING ORGANIZATION National Defense University		7b. ADDRESS (City, State, and ZIP Code) NDU-LD-SCH Ft. McNair Washington, D.C. 20319-6000	
6c. ADDRESS (City, State, and ZIP Code) Fort McNair Washington, D.C. 20319-6000		7c. ADDRESS (City, State, and ZIP Code) Fort McNair Washington, D.C. 20319-6000	
8a. NAME OF FUNDING / SPONSORING ORGANIZATION N/A		8b. OFFICE SYMBOL (If applicable)	
9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER N/A		10. SOURCE OF FUNDING NUMBERS	
8c. ADDRESS (City, State, and ZIP Code)		PROGRAM ELEMENT NO.	
		PROJECT NO.	
		TASK NO.	
		WORK UNIT ACCESSION NO.	
11. TITLE (Include Security Classification) <i>Information Age Partnership DoD Airwaves and the Microchip</i>			
12. PERSONAL AUTHOR(S) <i>Mr. JOSEPH E Sulick, Department of the Air Force</i>			
13a. TYPE OF REPORT Research		13b. TIME COVERED FROM Aug 95 TO Apr 96	
14. DATE OF REPORT (Year, Month, Day) April 1996		15. PAGE COUNT 48	
16. SUPPLEMENTARY NOTATION			
17. COSATI CODES			
FIELD GROUP SUB-GROUP			
18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)			
19. ABSTRACT (Continue on reverse if necessary and identify by block number) See Attached			
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input type="checkbox"/> UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
22a. NAME OF RESPONSIBLE INDIVIDUAL Susan Lemke		22b. TELEPHONE (Include Area Code) (202) 685-3957	
		22c. OFFICE SYMBOL NDU-LD-SCH	

DISCLAIMER

This research report represents the views of the author and does not necessarily reflect the official opinion of the Industrial College of the Armed Forces, the National Defense University, or the Department of Defense.

This document is the property of the United States Government and is not to be reproduced in whole or in part for distribution outside the federal executive branch without permission of the Director of Research and Publications, Industrial College of the Armed Forces, 408 4th Avenue, Fort McNair, D.C. 20319-5062.

Contents

Section	Page
DISCLAIMER.....	ii
ACKNOWLEDGMENTS.....	iv
ABSTRACT.....	v
I INTRODUCTION.....	1
II SPECTRUM ENVIRONMENT.....	3
Economic Frame.....	3
Domestic Frame.....	5
International Frame.....	6
Military Frame.....	7
III THE ISSUE.....	10
Why Is This So Hard To Do?.....	10
IV INFORMATION WARFARE.....	12
V ANALYSIS.....	15
VI RECOMMENDATION.....	20
VII WRAP UP.....	23
ENDNOTES.....	24
GLOSSARY.....	30
ACRONYMS.....	32
BIBLIOGRAPHY.....	35

Illustrations

Figure		Page
1	SPECTRUM MANAGEMENT STRUCTURE.....	5

Acknowledgments

The research and writing involved in this study would not have been possible without the support, encouragement, expertise, and patience of many people.

At the National Defense University's Industrial College of the Armed Forces, I owe special thanks to Dr. Bill Knowlton, Col., USA (RET), instructor in Strategic Decisionmaking. He sharpened my thinking and insured that I stayed on course.

At the National War College, Col. Dave Tretler (USAF), Dean of Faculty and Academic Programs, offered rethinking the joint environment and the evolution of the Services' culture to understand "jointness" complexities.

At the School of Information Warfare and Strategy, Mr. Brad Barriteau, Col., USMC (Ret)) advised of the concept of order in chaos. We'll see.

Within the Air Force Frequency Management Agency, Mr. Ken Williams, spectrum management "historian, " provided the needed supporting documents on time. That saved additional hours for more rewarding research endeavors. Ms. Rachel Flowers graciously "volunteered" to assume my responsibilities during my absence to help make this endeavor possible. Thank you both for your support.

I wish to thank my boss, Col Kimberly Dalrymple, commander of the Air Force Frequency Management Agency, for allowing me to attend ICAF during a period of intense spectrum management activity. She placed professional training of one of her individuals above her own agency's needs for potential future enrichment to DoD.

Finally, I wish to thank my family for their encouragement while I achieved the "ICAF experience." It was a challenge worth the effort.

I alone am responsible for technical errors or inadequacies in this paper.

JOSEPH E. SULICK, SR., DAF
Student
Industrial College of the Armed Forces

Information Age Partnership: DoD Airwaves and the Microchip

Joseph E. Sulick

Abstract

This paper focuses on DoD electromagnetic spectrum management and its significance to warfighting operations. It's about why spectrum is important to the nation's economy and how DoD elements compete with the private sector for this limited resource; it's about how DoD handles spectrum management in accordance with national and international laws; and it's about structure. The issue centers on how to do DoD spectrum management business better. The effort to consolidate all Service spectrum management elements under the Joint Staff continues to evolve in an uncertain direction, meeting stiff resistance in every corner of Service turf. The trend toward commercial systems will further compound the problem because of international laws that govern the spectrum. The threat of intrusion to spectrum-dependent military and commercial information systems also poses a significant risk to national security. Finally, this paper is about the need to expand this single joint entity concept one step further to aid the warfighter - the need to form a partnership between spectrum management, under J6 oversight, and information warfare, under J3 oversight, to aid command and control warfare (C2W), a supporting military strategy that implements information warfare on the battlefield and enhances the chances of success for the Joint Force Commander. As personnel resources diminish, individual performance must be optimized. The rebalancing of these critical functional areas into a joint partnership is essential to insure best value and best results to reduce the fog and friction of war and the vulnerability of DoD information systems.

Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur.

Giulio Douhet, in *The Command of the Air*

SECTION I

Introduction

We live in a rapidly evolving world that has changed dramatically since WW2. We no longer face a single, galvanized foe; instead, we are transitioning to an "Information Age" where the reduced and restructured military Services will rely increasingly on technology as a key element of strategy. Weapon systems must be highly accurate, lethal, and survivable for targets that may be fixed or mobile and well concealed. This dependence on high-tech weapon systems requires that DoD maintain the legal authorization to operate their communications-electronics equipment in the electromagnetic spectrum, the "invisible natural resource". The increasing dependence on technology introduces new vulnerabilities to the military and the nation. Adversary capabilities will steadily improve and will be difficult to anticipate. Technologies and processes that can exploit these vulnerabilities are available globally. Information will be the most respected weapon on the techno-battlefield into the 21st century. Spectrum management, and information warfare, are major players in this process.

This paper discusses managing spectrum dependent weapon systems in an interdependent relationship to gain maximum use of every allocated dollar. I set the stage by examining spectrum economics and its significance to the nation and DoD operations. Congress recognizes the spectrum as a source of income to help abate the federal budget deficit while DoD relies on spectrum-dependent high technology weapon systems in the conduct of military operations essential to the security of the United States. I address spectrum management through military,

domestic, and international frames. The military frame concerns the relationship between the combatant commands and the Services and spectrum management placement within the DoD structure. The domestic and international frames examine the laws that govern global spectrum management. The diversity of these laws increases the complexity of spectrum use for military operational units that train in the continental United States (CONUS) and may fight at long distances anywhere in the world. Section III examines how best to do DoD spectrum management. DoD efforts over the past two years to combine the Services' separate spectrum management functional elements into a single joint agency met stiff Service resistance, but they opened constructive dialogue on the need to explore new ways to accomplish DoD spectrum business better. However the efforts did not explore fully another event that is changing the DoD environment- information warfare. The threat of intrusions to military information systems poses a significant risk to national security. A fusion of both spectrum management and information warfare would aid offensive and defensive uses of the spectrum and DoD information operations.

I analyze three options for senior level DoD decisionmakers and conclude with a recommended optimum solution - the union of the spectrum management and information warfare functional areas to support a Joint Force Commander. I provide near-term, mid-term, and long-term phases to merge spectrum management and information warfare elements into a Joint Information Operations Center under the Joint Staff, Operations Directorate(J3). This partnership at the joint level will aid in achieving advantageous synergies, capitalizing on operational flexibilities, minimizing spectrum interference potential and conflicting objectives, establishing command and control priorities, and providing unity of purpose to meet the increasing hi-tech global requirements of the 21st century. This union will increase the combatant commanders' and Service agencies' ability to achieve DoD objectives delineated in the *National Military Strategy* through a

concentrated integration of these necessary command and control resources to protect friendly forces and exploit enemy vulnerabilities into the next century.

Section II

Spectrum Environment

Economic Frame

The monetary value of spectrum is enormous. Spectrum dependent technology, both commercial and military, cannot legally operate without spectrum authorization (frequency license). Expenditures for spectrum dependent commercial activities in the United States are valued at \$100 billion dollars annually.¹ Revenues from broadcasting and cellular radio services are estimated to exceed \$30 billion dollars annually.² Electromagnetic spectrum use underscores some of the most competitive and technologically oriented industries in the United States. It provides the foundation for multiple consumer and business services, such as radio and television broadcasting, cellular telephones, taxicab and emergency services' dispatch, and other radio based services. It represents a significant aspect in the economic wellness and global competitive posture for the United States. Federal government services also depend on its use to control air traffic, law enforcement, public safety, disaster relief, space program communications, and national defense. Congress has now recognized that the management and use of this resource should be a national policy objective.³

Spectrum use is an essential element of the U.S. communications infrastructure and its effective management promotes continuing U.S. economic and social development. At the national level there is growing concern that protracted administrative procedures and inflexible

regulation will not cope with increasing demands. Demand for spectrum is growing from both the expanded use of existing services and the development of new services, such as personal communications services (PCS), satellite-based mobile services, digital audio broadcasting, and advanced television.⁴ Congress has even authorized the FCC to use lotteries to choose among competing applicants in licensing some services.⁵ These lotteries failed to compensate the government for the private use of the resource.⁶ The lucky winner would often turn the license around and sell it for a higher price.⁷ So public auctions in 1994 were substituted for lotteries.⁸ Throughout United States history, government has cooperated with the private sector to promote competition and provide public goods. The electromagnetic spectrum is now recognized as a natural resource to enhance the nation's well-being.⁹

Looming in the background is information technology, the future primary source of national power. The intensified application of information technology to the battlefield indicates that information warfare will intensify in activity.¹⁰ Most of information warfare depends upon spectrum dependent communications-electronics equipment. DoD investments in advanced information systems will increase and less will be expended in tanks, planes, and ships. Even Sun Tzu indicated that careful planning based on sound information can contribute to speedy military decision making.¹¹

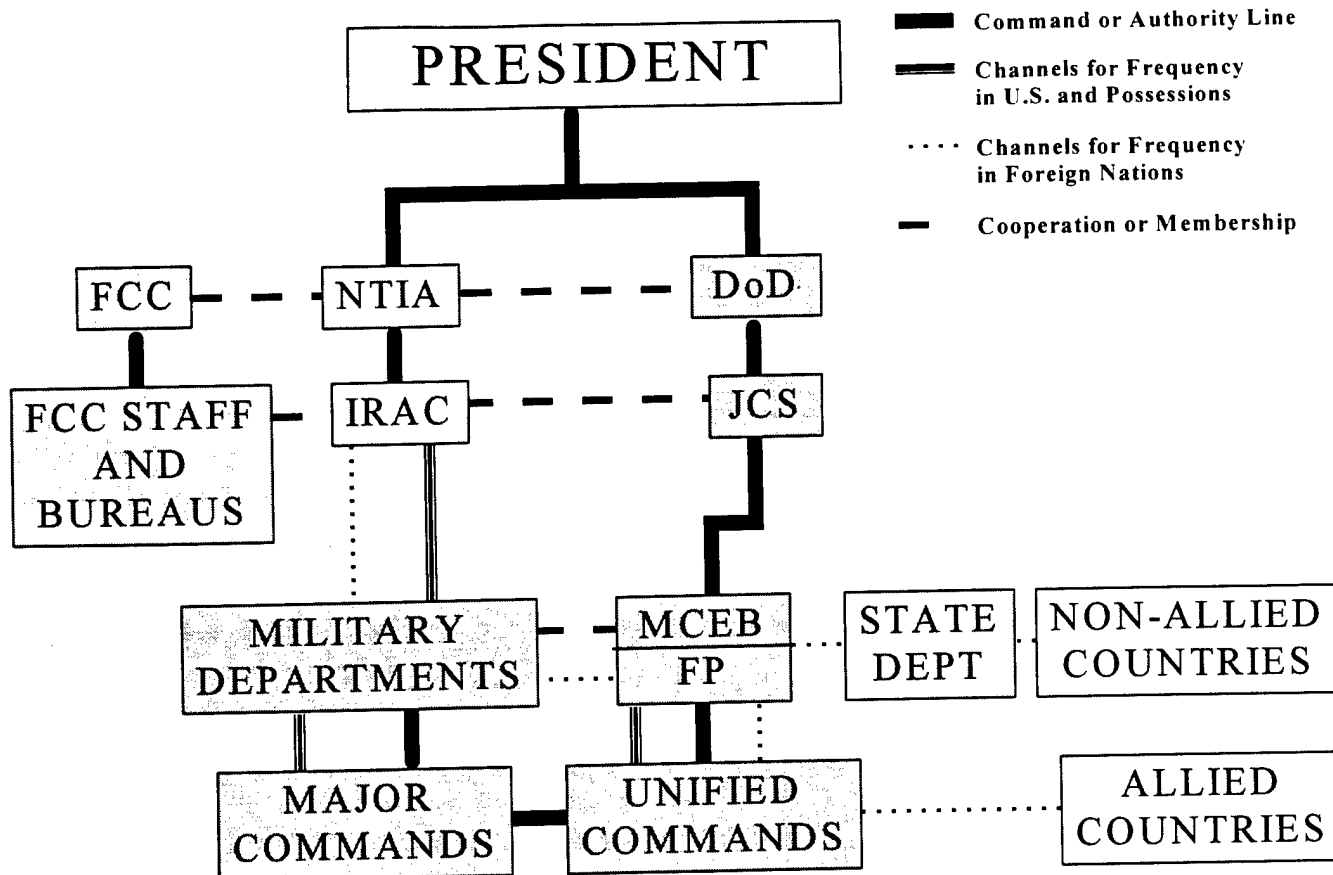


Figure 1. General Domestic and Military Spectrum Management Structure

Domestic Frame

Spectrum management authority in the U. S. is divided between the Federal Communications Commission (FCC) and the President (Figure 1 depicts the domestic and military spectrum structure which is explained in these sections). The Communications Act of 1934 established the FCC and provided it the authority to assign frequencies to radio stations in the United States except for those radio stations belonging to the federal government.¹²

Under section 305 of the Communications Act, the President is responsible for radio frequency assignments to federal government stations. The National Telecommunications and Information Administration (NTIA), currently under the Department of Commerce, is the executive branch agency responsible for developing national and international telecommunications policies in

accordance with federal and international laws.¹³ The head of this agency is the principal adviser to the President on telecommunications policies.¹⁴ The power of NTIA and the FCC combine to form the vision and leadership for the achievement of U.S. spectrum management policy goals.

The NTIA manages the federal government's use of the electromagnetic spectrum and establishes policies concerning the allocation, allotment, and assignment of spectrum for federal use based on the advice of the Interdepartment Radio Advisory Committee (IRAC).¹⁵ NTIA provides guidance to the various federal agencies and departments to ensure that radiocommunications activities are consistent with national policy.¹⁶ Each federal agency usually has a direct interest in a limited portion of the spectrum. Each military service has a representative appointed to the committee responsible for national level federal government operations.¹⁷

NTIA also assists in the development of the National Information Infrastructure (NII). Current initiatives involve the transfer of 200 megahertz (MHz) of spectrum to the non-federal radio users with increased pressure to allocate additional spectrum.¹⁸ This action is intended to benefit the public by promoting the development of new telecommunications technologies, products, and services that use the electromagnetic spectrum in accordance with the goal to "bolster America's economic revitalization" addressed in the *National Security Strategy of Engagement and Enlargement*.¹⁹

International Frame

On the international level, the International Telecommunication Union (ITU) establishes treaty level obligations that affect the nature and timing of any changes to a country's spectrum use.²⁰ The international arena is governed by a different set of rules and standards and services than that in the US.²¹ For example, equipment authorized for use in the US for a particular service (i.e., land mobile operations or wireless local area networks, both services used by the military) is most

likely unauthorized for operation in other regions of the world.²² This complicates training in the US and eventual deployment to other nations without prior host nation authorization.

Military Frame

The primary function of the Services is to provide forces organized, trained, and equipped to be employed by the combatant commander in the accomplishment of a mission.²³ The chain of command runs from the National Command Authorities (NCA) to the combatant commanders for missions and forces assigned to their commands and from the NCA to the Secretaries of the Military Departments for forces not assigned to a combatant commander. The Chair, Joint Chiefs of Staff (JCS), is the principal military advisor to the Secretary of Defense and the President. All components of DoD are charged to coordinate on matters of common or overlapping responsibility. The Joint Staff and Service headquarters have to maintain continuous coordination in this process. This process is currently inherent in the DoD spectrum management function via the Military Communications-Electronics Board (MCEB), the senior level group that addresses communications-electronics matters and coordinates issues among the DoD elements and the representatives of foreign governments.²⁴ Spectrum management matters are delegated to a working group termed the Frequency Panel (FP) composed of the Services' spectrum managers. The process to ensure successful coordination and interoperability in the spectrum management arena happens here. The FP addresses spectrum management issues that impact **all** DoD operations that use electromagnetic energy for a system. They assess spectrum management Service requirements with impact statements. Spectrum managers from all Services are members of the Frequency Panel as is a member of the Joint Staff (J6B).²⁵

At the Departmental level, the Office of Assistant Secretary of Defense for Command, Control, Communications, and Intelligence (OASD(C3I)) is tasked to ensure that DoD provides representation interdepartmentally and internationally on spectrum management matters.²⁶ The

Joint Staff, in coordination with ASD(C3I), is to provide guidance on joint and inter-service matters. The MCEB also delegated responsibility for a network of area frequency coordinators to the DoD agencies. This network's function is to promote frequency coordination within a designated national and Service test and training range.²⁷ The Directive also states that the Services are each individually responsible for spectrum management matters within their organizations.²⁸ Each Service maintains a spectrum management agency or element in some fashion at the headquarters level in Washington, DC, and implements spectrum management policy in support of individual Service Title 10 U.S.C. responsibilities and DoD Directive 5100.1. Each Service performs the following general spectrum management functions:²⁹

- Implements Service spectrum management policy in support of individual Service Title 10 U.S.C. responsibilities.
- Ensures Service use of the electromagnetic spectrum consistent with national, international, combined military, and multinational agreements.
- Represents Service-unique operational and technical spectrum requirements at joint, DoD, national, and international policy and regulatory functions.
- Manages Service spectrum certification programs for supportability of conceptual, experimental, developmental, and operational equipment in accordance with DoD Directive 5000.2.
- Provides policy guidance and procedural direction to Service's subordinate elements on Service, joint, national, and international spectrum matters.
- Provides Service representation to DoD, national and international spectrum management committees and working groups.
- Monitors the individual Service spectrum management automation architecture to ensure compliance with DoD automation standardization initiatives.
- Processes Service frequency assignments worldwide for legality.
- Provides spectrum management training and supports Service responsible DoD Area Frequency Coordinators.

Each Service has implemented separate spectrum guidelines and instructions based on the applicable national level policies and guidelines. Each Service has a single focal point at the headquarters level for spectrum management. Intermediate levels are differentiated among the Services. The Air Force uses spectrum managers at the Major Command level to obtain user spectrum requirements; the Army uses an intermediate agency at Fort Sam Houston to obtain their user requirements with the Corps of Engineers, the National Training Center and the Military

District of Washington reporting directly to the Army's headquarters element; the Navy maintains two intermediate elements on the East and West coasts to process their user spectrum requirements. The Marine Corps basically process their spectrum requirements through Navy channels. Each service is responsible for certain Area Frequency Coordinators (AFCs) that are assigned a geographical area of responsibility for a test and training range.³⁰ The responsibility for spectrum management for military operations planning is delegated to the J-6 directorates of the Unified Combatant Commands.³¹ Defense agencies, such as Defense Intelligence Agency, Defense Mapping Agency, Defense Logistics Agency, et. al., process their spectrum requirements through the appropriate Service Frequency Management Office in accordance with the applicable directive.³²

Training for spectrum management personnel is presently conducted at two locations. The Interservice Radio Frequency Management School (IRFMS) conducts a twelve week course at Keesler Air Force Base, Mississippi and the Army conducts a nine week Battlefield Spectrum Management Course (BSMC) at Fort Gordon, Georgia. Both schools were studied for potential consolidation but the feasibility of collocation was the only agreement reached among the Services.³³

A fixation on what was can blind us to what is, blocking the recognition of change.”

Robert B. Reich, in *The Work of Nations*

SECTION III

The Issue

Why Is This So Hard To Do?

Spectrum management has been the subject of intense DoD scrutiny over the past two years. A section of lessons learned in Desert Shield\Desert Storm indicated that spectrum support to the warfighter is inadequate.³⁴ The availability of trained and deployable support teams for joint operations is deficient. The lack of a single point of contact in DoD creates confusion in the coordination process. Spectrum management hinders the systems acquisition process; systems are procured and then cannot be operated as spectrum supportability is denied. Spectrum use is not synchronized on the joint battlefield as coordination between offensive and defensive users is unsatisfactory. DoD spectrum requirements are increasing at a time when spectrum availability is decreasing, and the perceived unwieldy DoD spectrum management structure cannot do the job.

Each Service evolved a structure to perform spectrum management in accordance with national and international laws. Organizational reengineering concepts, affectionately termed “rightsizing,” “downsizing,” “bottoms up,” “adaptive planning,” *et.al.*, emphasized the ubiquitous search for meaningful military structures. The Services studied “joint sizing” of the spectrum management element for the past two years. A DoD Inspector General (IG) audit conducted in 1993 concluded that the Services’ spectrum management activities should be combined into a

single entity.³⁵ This entity would produce increased effectiveness to the warfighter through a consolidation of functions.

The Services did not concur with the recommendations.³⁶ Multiple working groups within the Services were unsuccessful in the tasking to define roles and missions and a concept of operations for a spectrum management restructure. The Services were unable to reach consensus on the required military balance, executive agent, concept of operations, representation at national level working group committees, work force contributions, performance measurements, and the potential for incurred charges now organic to the Services.³⁷

Subsequently a Program Budget Decision(PBD) was enacted in December 1994 to force consolidation of the Services' spectrum management activities, although issues were unresolved.³⁸ In August 1995, the Joint Staff/J-6 sent a memo to OASD(C3I) requesting that PBD 082 be modified in order to return the Services to their respective spectrum management offices.³⁹ The Electromagnetic Compatibility Analysis Center(ECAC), located in Annapolis, MD, was renamed the Joint Spectrum Center (JSC) as the single focal point for the Joint Staff. The Services retained their spectrum management elements.⁴⁰

The intended purpose of the JSC was to consolidate joint, DoD, Service, and the Defense Information Systems Agency (DISA) spectrum management activities to achieve collective efficiencies in alleviating spectrum management deficiencies.⁴¹ The Services and the Joint Staff were unable to agree on an operational concept for this entity to provide added benefits to the Unified Commands and the Services. The three senior Service communications-electronics officers revealed the need for internal spectrum management processes that required joint coordination but not centralized administration.⁴² A revitalized MCEB FP could provide the centralized oversight of the spectrum without causing the Services to lose their internal spectrum management capabilities.

During this period of volatility, uncertainty, complexity, and ambiguity, the Services were fighting and losing some battles to retain federal government spectrum. Congress transferred some parts of the federal government spectrum to the commercial sector as a direct result of Title VI of the Omnibus Budget Reconciliation Act of 1993 (OBRA) and proposed new acts to transfer additional spectrum.⁴³ Diminished spectrum resources will provide equally diminished support to the national security capability. Less spectrum for military applications, such as radars, telemetry, radionavigation, weapons control and guidance systems, etc., results in an increased expenditure of time and resources for alternate capabilities (research, development, and testing). Systems replacement or systems relocation incur additional unacceptable costs in the current era of diminishing defense budgets. Planning for the management and use of the spectrum is now more critical than ever as the current legislated transfers of segments of valuable government spectrum will intensify DoD operational and readiness challenges for spectrum use of military weapon systems. Now let's explore two additional factors that impact DoD spectrum management - Information Warfare (IW) and Command and Control Warfare (C2W).

SECTION IV

Information Warfare

The United States is transitioning to an information age as a direct result of a technology revolution. The Services rely on high technology as a key element of strategy in order to support a smaller, highly mobile force. The pressure of fiscal limits, combined with the demands of regional conflicts, humanitarian support, and other non-traditional military missions, will put a premium on DoD high technology weapon systems. This rapid technological dependence requires that DoD maintain the legal authorization to operate this technology in the electromagnetic

spectrum. Service roles and functions are increasingly constricted within the limited authorized spectrum of their communications-electronics equipment to operate multiple weapon systems.

The information revolution strengthens the importance of multi-organizational networks. The information revolution favors the growth of these networks by making it possible for diverse, dispersed players to communicate, coordinate, and operate across large distances with better information than ever before.⁴⁴ As military resources decline, accurate information and assured communications will increase. Information facilities will become more lucrative targets as the information revolution accelerates, weapon systems become increasingly integrated, and processes become more automated. Information will be the most respected weapon on the techno-battlefield into the 21st century. The Information Age is changing all military operations by providing commanders with information unprecedented in quantity and quality.⁴⁵ Advanced information systems will enable commanders to see everything in a battlefield area. Integration of information systems into military operations has made military force enhancing information functions a more valuable target set for enemy exploitation and has increased vulnerabilities of the military communications infrastructure.⁴⁶ DoD is in the embryonic stages of recognizing the emergence of technologies and processes that can exploit these vulnerabilities. Many military information functions are spectrum dependent (surveillance, reconnaissance, weather, navigation, etc.). Information Warfare (IW) comprises this set of information strengths and weaknesses. It uses tools of national power to create a competitive advantage at the strategic level.

Information warfare is commonly defined as "actions taken to achieve information superiority by affecting adversary information, information-based processes, information systems and computer-based networks while defending one's own information, information-based processes, information systems and computer-based networks."⁴⁷ IW consists of actions taken to attack information (offense), defend information (defense), and exploit information.⁴⁸

Command and Control Warfare (C2W) is a military strategy that implements information warfare on the battlefield to support operations. It focuses on two disciplines - C2 Protection (defensive in nature) and C2 Attack (offensive in nature). Both disciplines involve the elements of Psychological Operations (PSYOP) and military deception to disrupt the enemy decision-making process; Electronic Warfare (EW) to *dominate the spectrum*; physical destruction to destroy critical nodes; and Operations Security (OPSEC) to protect friendly command and control systems. These elements mutually support each other in an integrated strategy and are further supported by intelligence. The integration of these five elements makes C2W an effective supporting strategy and force multiplier on the battlefield. U. S. military forces are dependent on effective C2 for decisions based on information that cause actions and reactions on the battlefield.

C2W is integrated into military strategy, plans, operations, exercises, training, communications architectures, computer processing, systems development, and professional education. The objectives are to control the information arena for exploitation while protecting military information functions from enemy action; exploit control of information to employ IW against the enemy; and enhance force effectiveness by developing military information functions.⁴⁹ Technological advances combined with decreased defense budgets and force reductions will accelerate incorporation of information technology into spectrum dependent military operations. The one who sees the battlefield best, and can react the quickest, will have the edge in future conflicts.

The element of C2W that is most spectrum related is electronic warfare. EW is military action that involves spectrum use or spectrum control. There is only one spectrum that all use to support friendly operations and degrade enemy operations. Presently joint spectrum management is under the auspices of J6, Command, Control, Communications, and Computers, who interfaces with the FP. On the other hand, spectrum deconfliction, the procedure for limiting the effects of

friendly electronic warfare operations on joint communications, is under J3, Operations. J2, Intelligence, supplies J3 with the spectrum being exploited (basically friendly frequencies put on the list of things not to impede). All must coordinate with each other to insure success on the battlefield, and J3 is the driver.

There is a strong need for DoD to integrate both spectrum management and the information warfare functional areas in order to support a Joint Force Commander.⁵⁰ Spectrum management databases provide weapon systems' locational, technical characteristics, performance, and potential susceptibility information. This can aid decisionmakers in assessing vulnerabilities of DoD owned and leased weapon systems to enemy C2W; countermeasures to enemy C2W can be developed. Both functions are critical to the Services and Unified Commands. Success on the battlefield requires functional integration. Spectrum management is involved in almost all of it.

SECTION V

Analysis

I will now analyze three options to address the issue:

Option 1: Maintain the Services' separate spectrum elements ("They're not broke!"). DoD spectrum management is a specialized and critical functional activity where no private capability exists or can be reasonably developed within budgetary constraints. The Federal government does not lease or pay for spectrum services or spectrum channels as the private sector does for a frequency license. DoD spectrum management coordination, processing, and licensing remain a service free of charge except for personnel costs and electromagnetic compatibility analysis studies performed by the JSC(which is fee-for-service). The DoD spectrum community already employs many of the innovative business practices used in the private sector.⁵¹ The Services'

spectrum management functional areas are decentralized. Spectrum managers located at JFMOs support the unified military operations of the combatant CINCs. Each Service maintains a spectrum management functional element to address individual Service issues and operations for building and equipping their force elements. Defense agencies are supported through a designated Service to address their issues. Area Frequency Coordinators are assigned at military test and training ranges and supported by a designated Service. A working group composed of all Services and the Joint Staff address spectrum management matters and CINC concerns. ASD(C3I) maintains linkage with international and national representatives on spectrum management matters. There is a course for inter-Service spectrum management training and a course for Army unique training. CINC representatives play an active role in assessing the adequacy and currency of the spectrum management course curriculum. Every CINC is responsible for training and integrating assigned forces. Spectrum managers assigned or apportioned to a CINC are graduates of a spectrum management course.

Service spectrum management elements have been consolidating spectrum management functions for many years in an effort to reduce costs. Despite an accelerated drawing down of military forces, spectrum management requirements have not declined but rather have increased because of the accelerating need for enabling technology in weapon systems in a reduced force structure. Spectrum managers provide customer responsiveness at acceptable costs by adopting practices tailored specifically to the national and international environment. Spectrum managers are not allied with a static set of business practices but implement a mix of practices that best meet the needs of the customer.

The structure and variety of the Services increases breadth, flexibility, and synergy to military operations. The Services provide the military capabilities essential to the accomplishment of missions assigned to the CINCs that improve joint military effectiveness.⁵² Each Service's

resource allocation decisions are affected by different constraints. There may have been increased layers of management over time as the size of this hierarchy grew. Today's successful, consolidated organizations, such as Microsoft and Johnson and Johnson, are composed of independent, small, self-governing units. The current decentralization of authority in spectrum management encouraged entrepreneurial practices and provided responsiveness to the customer. DoD spectrum managers know the customer, the needs, and promote information sharing. The consolidation of this function would be most cost effective if it were underutilized.

Option 1 is the path of least resistance as change is not required. However, if this option is implemented, it may be increasingly difficult to adapt to the new frontiers of jointness required for performance-based systems of systems.

Option 2: Consolidate Service spectrum management elements with the JSC under J6 authority. The JSC evolved from the *Electromagnetic Spectrum Management Strategic Plan* that encompassed seven DoD strategic planning objectives.⁵³ It would be the single spectrum manager for DoD. It would accomplish all the seven strategic planning objectives. All DoD spectrum management matters would flow through it, worldwide. It would maintain teams of military personnel for deployment to unified commands during joint exercises and operations. It would obtain spectrum certification for weapon systems in the acquisition process. It would maintain the spectrum management database. It would be the office of primary responsibility for DoD, national, and international regulations and policy. It would provide planning documents for current and future spectrum use in DoD. It would be responsible for the Electromagnetic Compatibility (EMC) program, the Electromagnetic Environmental Effects (E3) program, and the Joint Spectrum Interference Resolution (JSIR) program. It would be the functional manager of all spectrum management information systems. And finally it would be the functional manager of spectrum management and E3 training for the DoD, and manage the pool of personnel trained in

spectrum management.⁵⁴ It would do all this with the transfer of the respective Service spectrum management personnel and existing resources of the Electromagnetic Compatibility Analysis Center.⁵⁵ This is the solution that has met resistance to date.

Under this option there would be economies of consolidation to accommodate expanding spectrum demands; there would be a single focal point within DoD for spectrum matters; and there would be a primary agent for integration of spectrum activities with C2W and Intelligence. The JSC can maintain C2 protect location information, technical characteristics, performance, and susceptibility data. It can assess vulnerabilities of DoD owned and leased systems to enemy C2W. It can develop countermeasures to enemy C2W. It can frequency deconflict C2 protect EW, intelligence, and C3 operations. However, the FP must be revitalized with a charter and authority to respond to the total range of spectrum requirements by using the resources of the JSC and Service spectrum management infrastructures towards a common goal. The J6, CINCs, OASD(C3I), and MCEB must clearly define joint spectrum management roles. The command, operational, and technical coordination channels must be delineated. The CINCs and Services must define their problem resolution requirements. OASD(C3I) and J6 must target the crucial spectrum related issues bearing on military planning, acquisition, operations, and training and readiness. Operational support to the technowarrior must be a value added capability derived from the JSC core missions and resources.

Option 2 is an acceptable and suitable choice as an interim measure. This reinforces the ongoing attempt to establish a "one-stop" spectrum management element for the Joint Staff. It consolidates spectrum management bits and pieces and would increase visibility at OASD and the Joint Staff just by being part of the Joint Staff. However, it still does not dramatically alter the paradigm for spectrum-dependent military requirements and spectrum access in a power projection platform.

Option 3: Form a partnership between spectrum management and information warfare under J3 authority. Although there is neither national policy nor national laws that govern information warfare, information warfare is evolving similarly to the methodology in which spectrum management developed within DoD.⁵⁶ The threat of intrusions to the military and commercial information systems poses a significant risk to national security.⁵⁷ Military systems are becoming increasingly commercial off-the-shelf to keep pace with technology. Boundaries between DoD and non-DoD systems are blurring as systems interconnect; vulnerabilities increase in correlation to interconnectivity. Vulnerabilities are exploited through electronic means, PSYOP, and other measures designed to manipulate, deceive, disable, or destroy an opponent's information systems. Geography is becoming irrelevant in the world of cyberspace. The union of both spectrum management and information warfare would aid offensive and defensive uses of the spectrum and DoD information operations through C2W strategy. There is an opportunity now to increase combat effectiveness to aid the technowarrior in the 21st century with the union of the spectrum management and information warfare functional elements into a single joint agency to support C2W. The combined synergy of both functional elements would provide world-class electromagnetic spectrum and information warfare supremacy gained through integration of all their respective elements. Under J3 authority, joint warfighting can only be enhanced.

Option 3 offers the path of most resistance as it unites functional areas that are currently progressing in divergent directions. Spectrum management is firmly entrenched in law and structure; information warfare is nationally ungoverned and seeks direction. However, this union will best contribute to the needs of the evolving revolutionary changes in the military frame of the future- dominant battlespace knowledge. Commanders will have more information available in real time to remain focused on issues, the organization will be flattened and integrated, and staffs reduced.

If you don't know where you want to go, any road will get you there

- The Rabbit, in *Alice in Wonderland*

SECTION VI

Recommendation

The Department of Defense is structured with air, land, and naval capabilities to meet diverse contingency operations in a high technology environment with decreased future funding. The Services equip and train the personnel for the regional CINCs that conduct U.S. military operations, DoD's end product. Competition among the Services produces innovation in weapon systems development that produce the needed military capabilities to conduct military operations in accordance with U.S. National Military Strategy. The future for DoD consists of rapid change, diverse contingencies, limited budgets, and wide range of missions in a high tech environment. Every DoD functional area must support the regional CINCs to meet military requirements into the 21st century. DoD policy makers, the Services, the Joint Staff, and support agencies must work together to meld unified forces for the battlefield. Spectrum management is a key element on this stage as it is governed by both national and international laws; without it technowarriors could not train and fight. Information warfare uses command and control warfare strategy with spectrum dependent equipment to perform their role. The next decade will provide a quantum shift in the evolution of armed conflict. U.S. military forces will be designed to achieve dominant battlefield awareness and combat superiority through the deployment of fully integrated intelligence systems and technologically superior weapon systems, all primarily spectrum dependent. This involves

knowing the location of both the enemy and friendly forces and acting before the adversary's dominant battlefield awareness system can see U.S. forces act.

I support option 2 in the near term and option 3 for the long term. The following recommendations to implement this strategy are provided within a realistic and doable time frame:

- **Near term (1-2 years):**

1. Collocate all Service headquarters spectrum management offices to encourage cooperation and consensus building and save on DoD overhead costs.
2. Clarify and formalize the joint and interservice spectrum management and information warfare roles. There must be a clear delineation between the command and operational chain and technical coordination channels. The Joint Staff supports the CJCS, the NSC, and SecDef; ASD(C3I) is to provide policy advice, independent perspectives, and analytical support to SecDef. The spectrum management and information warfare communities serve a chain of command and support inter-boundary technical coordination. Integrated policy and procedural responsibilities will improve spectrum management and information warfare in theater.
3. Revitalize the Frequency Panel with a new charter and authority to respond to the total range of future spectrum requirements by using the JSC and Service spectrum management infrastructures and resources toward a common goal- support to the warfighter. The mission of directing these capabilities must be made available to the CINCs and Services to ease the transition to a common goal. The FP is the "one stop shopping" place for the CINCs near-term and provides the focal point within DoD for enhanced unity of effort and synchronization of spectrum management activities. It is the forum to prevent spectrum management oversights and omissions and is the strong proponent for a critical military resource.
4. Retain the Joint Spectrum Center for CINC spectrum management augmentation, electromagnetic compatibility analyses, standard DoD spectrum management automation,

and electromagnetic environmental effects program. The JSC is a world-class, state-of-the-art electromagnetic compatibility analysis element for resolving technical problems beyond Service and Agency capabilities. Their tools must be customer based and interoperable.

5. J3 and J6 must insure coordination between the FP and the IW Panel with the end product of eventual integration of resources.
6. Retain the DoD AFCs with the Services. J6 task FP to conduct feasibility study, in concert with affected AFCs, to determine future operational organizational structure.
7. Retain the two spectrum management training facilities(the InterService Radio Frequency Management School and the Army Battlefield Spectrum Management course) to ensure organic Service functions are satisfied. Track the Commission on Roles and Missions' proposed creation of a functional unified command for joint training and force integration. This command could focus on training of spectrum management and information warfare for the joint environment to best serve CINC requirements.

- **Mid-Term (2-4 years).**

1. OASD(C3I) task J3 and J6 to initiate actions to integrate information warfare and spectrum management functional areas, including the JSC, into a Joint Information Operations Center under the J3. This incorporation will allow the joint commander to shape forces and capabilities to confront the enemy in combat under advantageous conditions- the essence of strategy.

- **Long Term (5 years +).**

1. Establish the Joint Information Operations Center under the Joint Staff, Operations Directorate(J3) by FY01. C2W strategy is a function of J3. The focus will be to negate or

convert to friendly advantage any adversary efforts to deny information to, influence, degrade, or destroy the friendly C2 systems.

2. Merge spectrum management specialty codes with command and control warfare specialty codes to provide depth in cross training.

SECTION VII

Wrap Up

The changing threat requires that C2W strategy be flexible and precise in targeting support to the point of need. As resources decline, the demands for on-line, accurate information and assured communications will increase. Weapon systems will become more integrated and processes more automated. U.S. forces will be designed to achieve dominant battlefield awareness and combat superiority through the deployment of these integrated and technologically superior weapon systems. The partnership of spectrum management and information warfare at the joint level will achieve advantageous synergism, capitalize on operational flexibility, minimize spectrum interference potential and conflicting objectives, establish priorities, and provide unity of purpose to meet the requirements for the technowarrior of the 21st century. Streamlining to a tighter integration of these functional elements through a concentration of command and control resources and a focus to C2W strategy to protect friendly forces and exploit enemy vulnerabilities will increase the combatant commanders' ability to achieve DoD objectives well into the next century.

ENDNOTES

¹ U.S. Department of Commerce. *Spectrum Reallocation Final Report*. Washington: NTIA Special Publication 95-32, February 1995, 1-2. The primary alternative to spectrum use is wire or a related fiber based technology. However I do not see much application for military units that must deploy for a regional conflict strategy as they are fixed links. Perhaps there is application for stateside communications infrastructure that can preserve the finite spectrum resource.

² U.S. Department of Commerce. *U.S. Spectrum Management Policy: Agenda for the Future*. Washington: NTIA Special Publication 91-23, February 1991, 13.

³ Numerous publications have expressed Congress's interest in the spectrum of which the most applicable is the editorial in the Wall Street Journal, July 27, 1990, *Congress's Wheel of Fortune*.

⁴ The accommodation of new technologies is exasperated when a frequency application is developed that does not conform to an existing defined service. Existing users have little incentive to accommodate a new service. Current users would incur added costs to update their equipment, or worse, completely replace equipment in a time of tight dollars. Outdated technology becomes entrenched. The combination of new technology and crowded space produce pressures for more channels with a narrower band width.

⁵ The FCC employed lotteries in 1983 to process cellular telephone and low power television applications. The result was an increase in the number of services.

⁶ *Economic Report of the President*. Washington: GPO, February 1995, 161.

⁷ Non-federal licenses are transferable and are often transferred as a part of a sale to another company. This leads to the concept of spectrum management "property rights" and spectrum "leases" beyond the scope of this paper but noted as a competitor for future spectrum further complicating military operations. An authorization provided by the FCC for operation on a specific frequency is called a "license." Federal government users are authorized an "assignment." This license or assignment decides who is authorized to use a discrete radio frequency or channel under specified conditions. An allocation, on the other hand, determines how a specific radio frequency band should be used by a radio service, i.e., broadcasting, landmobile, satellite, etc.

⁸ Economists recognized the advantages of auctioning spectrum licenses. It puts "the license directly in the hands of the applicant who values it most and is likely to provide the most aggregate value to the public." (*Economic Report of the President, op.cit.*, 161-162) It allows the public to share in the financial benefits that accrue from the use of the resource; its uses can be regulated to protect the public interest; and they are less costly and more efficient than lotteries and comparative hearings (terms economists like to hear). Cost effectiveness in spectrum management infers that users would have spectrum conserving incentives to use technology to the point (but not beyond) at which the cost of saving an additional unit of spectrum through technology equals the cost of purchasing an equivalent unit through the market based spectrum management system.

⁹ Nationally the spectrum to 300 GigaHertz is allocated as about 2% federal exclusive, 6% non-federal exclusive, and 92% shared; the more desirable spectrum below 30 GigaHertz is about 7% federal exclusive, 33% non-federal exclusive, and 60% is shared. Shared allocations have both primary and secondary services with primary services awarded protection from secondary services. Note that sharing is the name of the game in spectrum management. Military users should be made more aware of this aspect for their operations through military training programs to minimize interference potential.

¹⁰ Robert Neilson and Charles Giasson expound on this theory in "Information-the Ultimate Weapon," *Signal*, April 1994, 545-549.

¹¹ Sun Tzu, *The Art of War*, London: Oxford University Press, 1970, x.

¹² The Communications Act of 1934 and amendments do not define the criteria by which the FCC is to judge the public interest. The FCC has broad discretion to define content of the public interest. The administrative finding of the public interest constitutes the primary formal standard for apportioning non-federal spectrum and it varies for the different services. The House and Senate passed a Telecommunications Bill on

February 1, 1996, that would deregulate non-federal government spectrum. The President signed this measure on February 7, 1996. . Basically telephone, television, and computer services are impacted. See Mike Mills, "Telecommunications Bill Passed," *Washington Post*, February 2, 1996, A1, A15.

¹³ NTIA generally adheres to the standards and procedures for spectrum management matters delineated in the "Manual of Regulations & Procedures for Federal Radio Frequency" that is incorporated into 47 CFR Part 100. NTIA maintains this manual with the advice of the federal government agencies and issues revisions several times a year.

¹⁴ Executive Order 10246 provides the authority. Section 2-401 requires that NTIA develop policies in the overall national interest rather than just being limited to federal government agencies. This is often overlooked in the committee work of the federal government agencies. Also noteworthy is that the Department of Commerce is taking its hits with Congress in the reengineering effort. Representative Dick Chrysler (R-Michigan) is leading the dismantling package and NTIA is recommended for elimination. Even FCC is under scrutiny (see Keyworth, "Let's Say Goodbye to the FCC," *Washington Post*, May 16, 1995, D1-D6. The spectrum management structure of the federal government is more automated and responsive to the customer than the FCC.

¹⁵ The role of the IRAC was recognized in Executive Order 12046, 3 CFR, 1978 Comp 158, reprinted in 47 U.S.C. & 305 app. At 115 (1989), section 2-502. The IRAC advises NTIA on spectrum management matters. The Administrator of NTIA is the ultimate authority in all spectrum management decisions for the federal government. Appeals go to the Director of OMB.

¹⁶ OMB Circular A-11 requires that federal users obtain certification of spectrum support (certification that systems are compatible with existing and planned stations) *before* developing and procuring equipment. This is a powerful tool that is often abused by users and creates chaos in spectrum fora.

¹⁷ The IRAC consists of 20 voting members and a liaison representative from the FCC. The Army, Air Force, Navy and Coast Guard are voting members; Navy represents the USMC. The members of the Frequency Assignment Subcommittee recommend frequencies for approval to the IRAC who forwards to NTIA for approval. Generally all frequencies that survive these two committees are authorized for operation.

¹⁸ Title VI, *Omnibus Budget Reconciliation Act of 1993*, August 10, 1993.

¹⁹ U.S. President (Clinton). *A National Security Strategy of Engagement and Enlargement*, The White House: February, 1995, i.

²⁰ ACP 190, US SUPP-2, *Coordination and Registration of Frequencies Used by U.S. Military Forces on Foreign Soil*, June 1990, Confidential. This document governs formal and informal spectrum management procedures to coordinate U.S. military requests for frequency clearance in host countries. The ITU is a specialized agency within the United Nations that deals in telecommunications. Its purpose is to maintain and extend international cooperation for the improvement of telecommunications of all kinds. The ITU sponsors regional or world administrative radio conferences to revise and update the international rules, regulations, and procedures that have treaty status among the signatories. Preparation of U.S. positions and proposals for these conferences is a multi-year process of negotiation and planning by multiple U.S. organizations in spectrum management. Military operators need to plan for spectrum management changes in their operations in the international arena. The real power of the international spectrum management community is the International Frequency Registration Board (IFRB) under the aegis of the ITU.

²¹ For example, the NATO arena has special frequency concerns and has a special frequency agency called the Allied Radio Frequency Agency (ARFA) to cope with Allied use of the spectrum in the European theater. There is also another board composed of members from Australia, New Zealand, Canada, United Kingdom and the United States, called the Combined Communications Electronics Board (CCEB), to deal with communication electronics matters among these five nations.

²² For the purpose of frequency allocation the ITU has divided the world into three geographical regions. Types of service generally vary between regions according to international agreement. For example, wireless Local Area Networks (LANs) used in units in the United States cannot deploy to the Middle East and expect to operate on these units. To further complicate spectrum matters, each nation retains the right to depart from the guidance of the International Table of Frequency Allocations to meet its particular needs.

²³ Four decision-making support processes aid this process. The Joint Strategic Planning System (JSPS) and the weapons oriented requirements generation system process support the CJCS and are managed by the Joint staff. The Acquisition Management System and the Planning, Programming, and Budgeting System (PPBS) support SecDef and are managed by the OSD staff. The goal of these processes is to field the best mix of forces, material, and support to accomplish national security objective within budget.

²⁴ DoD Directive 5100.35, *Military Communications-Electronics Board*, May 6, 1985, is the governing directive. The members of the MCEB are: JCS/J6 (Chair), the Army, Navy, Air Force and Marine Corps senior communicators, DISA, NSA, and JTC3A representatives.

²⁵ However it must be noted that there is no full-time dedicated staff to the FP. Personnel resources of the FP are full time spectrum managers from the Services and Joint staff. It lacks the authority and responsibility to address future spectrum management concerns.

²⁶ DoD Directive 4650.1, *Management and Use of the Radio Frequency Spectrum*, paragraph E.2.

²⁷ Allied Communication Publication-190 US SUPP-1(C), "Radio Frequency Management within the United States Department of Defense," states the area frequency coordinators* military responsibilities, geographic areas of responsibility, and command structure. They also have responsibilities as Government Field Level Coordinators as delineated in the *Manual of Regulations and Procedures for Federal Radio Frequency Management*.

²⁸ Each Service has a strategic leader responsible for spectrum management. The Assistant Chief of Staff for Operations and Plans for C4 is the Army focal point; the Director of Naval Communications Division is the Navy focal point; and the Director for C4 (HQ USAF/SC) is the Air Force focal point. Each focal point maintains an element that performs the daily management of spectrum management activities, i.e., committee representation to ensure Service compatibility, impacts on Service operations, training, etc.

²⁹ This is a general compilation derived from the Services' spectrum management manuals or instructions. Air Force Instruction 33-118, *Radio Frequency Spectrum Management*, 1 October 1995; Army Regulation 5-12, *Army Management of the Electromagnetic Spectrum*; and the Navy's NAVTELCOMINST 2400.1, *Management and Use of the Radio Frequency Spectrum within the Department of the Navy*, 19 October 1989, provide the general spectrum management guidance for the Services. The author identified 212 documents that govern national and international spectrum management matters.

³⁰ The three Air Force DoD AFCs are at Nellis AFB, NV, Eastern at Patrick AFB, FL, and Gulf at Eglin AFB, FL. The two primary Navy AFCs are at Pt. Mugu, CA, and Norfolk, VA. The three Army AFCs are at White Sands, NM, Kwajalein in the Marshall Islands, and Fort Huachuca, AZ. This complex organizational structure, although effective, does have its detractors and the call for reform. But AFCs do their job well. The Army intermediate level is termed the Army Frequency Management Office (AFMO) - CONUS. AFMO-CONUS makes assignments for the Army. The Air Force and Navy headquarters elements make assignments for their respective Services.

³¹ Joint Frequency Management Offices (JFMOs) are established in Norfolk, VA, Honolulu, HI, and MacDill AFB, FL for the CINCLANT, CINCPAC, and CINCCENT areas respectively. CINCSOUTH has a Frequency Management Office in Quarry Heights, Panama. CINCSPACE, CINCTRANS, CINCUSOCOM, and CINCSTRATCOM do not have frequency management offices but process their frequency matters through the appropriate Service agency on their installations, predominantly Air Force spectrum management elements. The Joint Frequency Management Office Europe, located in Vaihingen, Germany, was established December 20, 1995, as the focal point for coordinating spectrum requirements with the nations in the USEUCOM area of responsibility.

³² ACP 190, US SUPP-1(C), *op.cit.*, paragraph 211 governs Service spectrum management responsibilities for the Defense agencies.

³³ Final report, "Interservice Training Review Organization (ITRO) Detailed Analysis Group (DAG) recommendations for Communications and Information Technology Training Studies," U.S. Army Signal Center, Fort Gordon, GA., August 11-12, 1994, p.3, paragraph 5.

³⁴ It must be noted that electronic combat inadequacies identified from lessons learned in Desert Shield/Desert Storm provided the catalyst for this report. Spectrum management deficiencies identified were

mainly attributed to lack of preparation on the part of the CINC and not because of Services' spectrum structure. Desert Shield/Desert Storm also demonstrated the effective use of electronic systems as force multipliers on the battlefield.

³⁵ Memorandum from Office of the Inspector General to the Deputy Secretary of Defense, et.al, "Audit Report on DoD's Evaluation and Analysis of Electronic Combat," Project No. 2AB-024, March 1993.

³⁶ The Army nonconcurred as the report was incomplete in addressing frequency support critical to Army missions(memo from LTG Pete Kind, US Army Director of Information Systems for C4, to the IG, May 24, 1993). The Air Force nonconcurred with the finding and recommendation as written in the audit report, but did concur that the spectrum management organizational infrastructure needed streamlining and restructuring(memo from LTG Carl O'Berry, USAF Director for C4, to the IG, May 27, 1993). OASD/Defense-Wide C3, nonconcurred pending results and recommendations of the OASD spectrum management functional and economic analysis using business process reengineering methodology(memo from Mr. John Grimes, Deputy Assistant Secretary of Defense for Defense-Wide C3, to the IG, May 26, 1993). The Joint Staff and Navy nonconcurred with the report but did not respond to it.

³⁷ Director of the Joint Spectrum Center Migration Team briefing presented to the MCEB on 19 August 1994. The MCEB is the DoD senior level communications-electronics board. The author was the Air Force member on this team.

³⁸ Program Budget Decision 082, *Defense Investigative Service(DIS) and the Joint Spectrum Center(JSC)*, December 5, 1994.

³⁹ J6 memorandum to OASD(C3I), "Joint Spectrum Center," August 9, 1995. OASD(C3I) responded to J6 in a memorandum on August 24, 1995, with the concurrence that the Joint Spectrum Center is an important initial step in improving spectrum support to the warfighter.

⁴⁰ DoD Directive 5160.57, *Electromagnetic Compatibility Analysis Center*, September 23, 1966, provided the initial responsibilities and are now incorporated in DoD Directive 3222.3. ECAC evolved in the early 1960's as a result of electromagnetic interference in testing programs. Their resources consist of 45-50 federal government personnel, both military and civilian, and a sole contractor of 500-650 personnel. ECAC is located in Annapolis, MD and their location was approved by the BRAC in 1995 for deactivation.

⁴¹ Memorandum from the Chairman of the Military Communications-Electronics Board to the Assistant Secretary of Defense (Command, Control, Communications and Intelligence), *Establishment of a Joint Spectrum Center*. December 15, 1993. Memorandum from the Assistant Secretary of Defense (Command, Control, Communications and Intelligence) to the Secretaries of the Military Departments, Chairman of the Joint Chiefs of Staff, and Directors of the Defense Agencies, *Creation of a Joint Spectrum Center*. February 25, 1994. Memorandum from the Assistant Secretary of Defense (Command, Control, Communications and Intelligence) to the Secretaries of the Military Departments, Chairman of the Joint Chiefs of Staff, and Directors of the Defense Agencies, *Creation of a Joint Spectrum Center*. October 17, 1994. (Modified February 25, 1994 memo)

⁴² Joint memo from VADM Davis (USN), LTG Guenther (USA), and LTG O'Berry (USAF) to OASD(C3I), *Joint Spectrum Center*, 28 April 1995.

⁴³ Title VI was the legislated transfer of government spectrum to the public for exploitation of emerging telecommunications technologies. The federal government was to transfer 235 megahertz to FCC for auction (estimated \$10B in revenues) during the period 1994-2004. Additional government spectrum is being sought for transfer to the private sector to generate additional revenue and aid in telecommunication de-regulation.

⁴⁴ John Arquilla and David Ronfeldt, *Cyberwar Is Coming*, Rand Corp. Santa Monica, CA, 1992, 3. Also James R. Golden, *Economics and National Strategy in the Information Age*, Westport: Praeger, 1994, 14-19.

⁴⁵ Air Force Chief of Staff paper, *Cornerstones of Information Warfare*, 1995, 1. ADM William A. Owens, "The Emerging Systems of Systems," Naval Institute Proceedings, May 1995, 35-39.

⁴⁶ William J Martin, *The Information Society*. London: Aslib, 1988. 58

⁴⁷ DoD Directive 3600.1, *Information Warfare*, is in draft at the time of this writing.

⁴⁸ As noted in the AF's *Cornerstones of Information Warfare*, there is an offense-defense asymmetry in the scope of IW. The military may attack any militarily significant target that has a bearing on his will to fight, but the military can only defend military information functions. There are multiple governmental, industrial, and private organizations in the U.S. that are not under DoD's purview. Bob Schneider and Greg Frick, students at the School of Information Warfare and Strategy, termed offensive information warfare, "information attack", and defensive information warfare "information assurance", in their paper "A National Security Strategy for the Information Age", October 4, 1995. The authors also recommended that an IW national strategy was needed to develop an information assurance program in concert with the private sector to insure U.S. national security in the Information Age. The National Security Council would take the lead in this effort.

⁴⁹ There is a need to address counterinformation (controlling the information arena), C2 attack (any action against the enemy's C2 system), and information operations (any action involving the acquisition, transmission, storage, or transformation of information that enhances the employment of military forces) into doctrine. DoD Directive 3600.1(draft), *Information Warfare*, CJCSI 3210.11(draft), *Information Warfare Policy*, and CJCSI 3110.09, *Command and Control Warfare*, are current initiatives in these arenas.

⁵⁰ Please note that an IW Panel under J38 collateral with J6K was recently established. The FP is under the auspices of J6B. The Naval IW Agency at Fort Meade, MD, provides the operational arm to support FLTCINCs and maintains a detachment in San Diego, CA. The Navy's Fleet Information Warfare Center (FIWC) was established in Norfolk, VA on October 1, 1995 with about 194 authorized positions. See *Inside the Navy*, September 18, 1995, 5. The Air Force Information Warfare Center in San Antonio, TX, employs about 1,000 personnel to support IW planning, intelligence gathering, weapon system analysis, and related activities. The Army Land IW Activity is located at Fort Belvoir, VA. The Air Force merged information management and C4I functions in January 1996. This created a new career field called "communications and information" that will impact about 85,000 personnel and set the stage for the Air Force vision for information dominance. See *Air Force* magazine, March, 1996, 15.

⁵¹ *Benchmarking for Electromagnetic Spectrum Management Best Practices*, Frequency Panel Benchmarking Team Report to the MCEB Frequency Panel, January 30, 1995. This report received the Bronze Medal for a Benchmarking Study Award on November 3, 1995. The International Benchmarking Clearing House located in Houston, Texas, evaluates submissions annually. *CIM Modeling Study of DoD Management and Use of the Electromagnetic Spectrum*, J208Z Permanent Working Group Frequency Panel Activity Based Costing Workshop Report to the MCEB Frequency Panel, July 25, 1994.

⁵² U.S. Commission on Roles and Missions of the Armed Forces, "Directions for Defense: Report of the Commission on Roles and Missions of the Armed Forces," May 24, 1995, 2-20.

⁵³ The original roots evolved from deficiencies identified from Operation DESERT SHIELD/DESERT STORM. Light bulbs clicked on that spectrum management is critical to non-fratricidal military operations and that spectrum support must be improved for Command and Control Warfare (C2W, nee C3CM). The seven strategic planning objectives identified in the *DoD Electromagnetic Spectrum Management Strategic Plan* are to "ensure that the warfighter receives effective spectrum support for military operations; ensure effective management and efficient use of spectrum resources; ensure that efficient use of the electromagnetic spectrum is considered in the research and development and acquisition of weapon systems; capitalize on technological innovation for conservation and better use of the spectrum; streamline the Department's spectrum management infrastructure to conserve resources and facilitate interaction with other government agencies and the civil sector; ensure effective DoD training and career development for spectrum management and technology; and ensure an effective electromagnetic radiation hazard protection program."

⁵⁴ *Ibid*, Chapters 2 and 3. Also noted in the draft Concept of Operations for the Joint Spectrum Center, May 25, 1995.

⁵⁵ JSC requested funding as follows: FY96 - \$20.7M; FY97 - \$20.9M; FY98 - \$20M; FY99 - \$19.7M; FY00 - \$20.1M; and FY01 - \$20.4M. PBD 082 funding was: FY96 - \$10.668M; FY97 - \$10.331M; FY98 - \$10.654M; FY99 - \$11.034M; FY00 - \$11.334M; and FY01 - \$11.748.

⁵⁶ U.S. Commission on Roles and Missions of the Armed Forces, "Directions for Defense: Report of the Commission on Roles and Missions of the Armed Forces," *op.cit.*, 2-15.

⁵⁷ *A National Security Strategy of Engagement and Enlargement, op.cit*, 68.

Glossary

Command and Control: The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of a mission.

Command and Control Warfare: The integrated use of operations security, military deception, psychological operations, electronic warfare, and physical destruction, mutually supported by intelligence, to deny information to, influence, degrade, or destroy adversary command and control capabilities, while protecting friendly command and control capabilities against such actions. Command and control warfare applies across the operational continuum and all levels of conflict. Also called C2W. C2W is both offensive and defensive: a. counter-C2- To prevent effective C2 of adversary forces by denying information to, influencing, degrading, or destroying the adversary C2 system. b. C2-protection- To maintain effective command and control of own forces by turning to friendly advantage or negating adversary efforts to deny information to, influence, degrade, or destroy the friendly C2 system. (Joint Pub 3-0, 1 Feb 95).

Deconfliction: The process of satisfying conflicting spectrum usage requirements where C2 and EW systems are operated simultaneously in battle. (Joint Pub 3-13)

Electromagnetic Compatibility: The ability of systems, equipment, and devices that use the electromagnetic spectrum to operate in their intended operational environments without suffering unacceptable degradation or causing unintentional degradation because of electromagnetic radiation. Also called EMC.

Electromagnetic spectrum: The range of frequencies of electromagnetic radiation from zero to infinity.

Electromagnetic spectrum allocation: The designation of frequency bands for use in performing specific telecommunication functions and services. Also called frequency allocation.

Electromagnetic spectrum assignment: The authorization granted by an administration for a radio station to use a radio frequency channel under specified conditions. Also called frequency assignment.

Electronic warfare: Any military action involving the use of the electromagnetic and directed energy to control the electromagnetic spectrum or to attack the enemy. Also called EW. (Joint Pub 3-0, 1Feb 95).

Electromagnetic Environmental Effects: The impact of the electromagnetic environment upon the operational capability of military forces, equipment, systems, and weapon platforms. It encompasses all electromagnetic disciplines. Also called E3. (Joint Pub 1-02).

Information: Data and instructions.

Information operations: Any action involving the acquisition, transmission, storage, or transformation of information that enhances the employment of military forces.

Information Warfare: Actions taken to achieve information superiority by affecting adversary information, information-based processes, information systems and computer-based networks while defending one's own information, information-based processes, information systems and computer-based networks.

Military deception: Actions executed to mislead foreign decisionmakers, causing them to derive and accept desired appreciations of military capabilities, intentions, operations, or other activities that evoke foreign actions that contribute to the originator's objectives. (Joint Pub 3-0, 1 Feb 95).

Operations security(OPSEC): A process of identifying critical information and subsequently analyzing friendly actions attendant to military operations and other activities to: a. Identify those actions that can be observed by adversary intelligence systems. B. Determine indicators hostile intelligence systems might obtain that could be interpreted to derive critical information in time to be useful to adversaries. C. Select and execute measures that eliminate or reduce to an acceptable level the vulnerabilities of friendly actions to adversary exploitation. (Joint Pub 3-0, 1 Feb 95).

Psychological operations(PSYOP): Planned operations to convey selected information and indicators to foreign audiences to influence their emotions, motives, objective reasoning, and the behavior of foreign governments, organizations, groups, and individuals. The purpose of psychological operations is to induce or reinforce foreign attitudes and behavior favorable to the originator's objectives. (Joint Pub 3-0, 1 Feb 95).

Spectrum management: The function where use of the electromagnetic spectrum is controlled to insure electromagnetic compatibility of communications-electronics systems. Also called electromagnetic spectrum management or radio frequency management.

Telecommunication: Any transmission, emission, or reception of signs, signals, writings, images, sounds, or information of any nature by wire, radio, visual, or other electromagnetic compatible systems.

Acronyms

AFC	Area Frequency Coordinator
AFMO	Army Frequency Management Office
ARFA	Allied Radio Frequency Agency
BSMC	Battlefield Spectrum Management Course
C2	command and control
C2W	command and control warfare
C3	command, control, and communications
C3CM	command, control, and communications countermeasures
C4	command, control, communications, and computers
CINC	Commander in Chief
CJCS	Chairman of the Joint Chiefs of Staff
COCOM	combatant command
counter-C2	counter command and control
DAG	detailed analysis group
DISA	Defense Informations Systems Agency
DoD	Department of Defense
E3	electromagnetic environmental effects
ECAC	Electromagnetic Compatibility Analysis Center
EMC	electromagnetic compatibility
EO	executive order
EW	electronic warfare
FCC	Federal Communication Commission
FP	Frequency Panel

IG	Inspector General
IRAC	Interdepartment Radio Advisory Committee
IRFMS	Interservice Radio Frequency Management School
ITRO	Interservice Training Review Organization
ITU	International Telecommunications Union
IW	information warfare
JCS	Joint Chiefs of Staff
JFMO	Joint Frequency Management Office
JOIC	Joint Information Operations Center
JSC	Joint Spectrum Center
JSIR	joint spectrum interference resolution
LAN	local area network
MCEB	Military Communications-Electronics Board
MHZ	megahertz
MILDEP	military department
MOP	Memorandum of Policy
NATO	North Atlantic Treaty Organization
NII	National Information Infrastructure
NSC	National Security Council
NTIA	National Telecommunications Information Agency
OASD	Office of the Assistant Secretary of Defense
OBRA	Omnibus Budget Reconciliation Act
OPSEC	operations security
PBD	program budget decision
PCS	personal communication services

PSYOP	psychological operations
SECDEF	Secretary of Defense

Selected Bibliography

- Air Force Instruction 33-118, *Radio Frequency Spectrum Management*, 1 Oct 95.
- Allied Communication Publication, US Supplement -1, "Radio Frequency Management within the United States Department of Defense," 21 June 1989.
- Allied Communication Publication, US Supplement -2, "Coordination and Registration of Frequencies Used by US Military Forces on Foreign Soil," June 1990, (Confidential).
- Army Regulation 5-12, *Army Management of the Electromagnetic Spectrum*.
- Arquilla, John, and David Ronfeldt, "Cyberwar Is Coming," Santa Monica: RAND Corporation, 1992, 3-4.
- Barr, Stephen, "Commerce Dept. Can't Shake Freshman Lawmaker," *Washington Post*, October 10, 1995, A11.
- "Benchmarking for Electromagnetic Spectrum Management Best Practices," Frequency Panel Benchmarking Team Report to the MCEB Frequency Panel, January 30, 1995.
- Blair, Margaret M. *Ownership and Control: Rethinking Corporate Governance for the Twenty-first Century*. Washington, D.C.: The Brookings Institution, 1995.
- Bolman, Lee G., and Terrance E. Deal. *Reframing Organizations: Artistry, Choice, and Leadership*. San Francisco: Jossey-Bass Publishers, 1991.
- Brown, Ronald H., "Private-Public Partnerships Are at Work to Develop Technologies of the Future," *Washington Post*, May 16, 1995, D2.
- Chairman of the Joint Chiefs of Staff(CJCS) Memorandum of Policy(MOP) 30. *Command and Control Warfare*. 1st revision. 8 March 1993.
- Chairman of the Joint Chiefs of Staff(CJCS) Memorandum of Policy(MOP) 64. *Joint Spectrum Management*, undated.
- Chairman of the Joint Chiefs of Staff(CJCS) Memorandum of Policy(MOP)185. *Command, Control, and Communications Countermeasures* 20. December 1983.
- "CIM Modeling Study of DoD Management and Use of the Electromagnetic Spectrum," J208Z Frequency Panel Working Group Activity Based Costing Workshop Report to the MCEB Frequency Panel, July 25, 1994.
- "Concept of Operations for the Joint Spectrum Center"(draft), 25 May 1995.

- Correll, John T., "Surprise Package on Roles and Missions," *Air Force Magazine*, August, 1995, 15-17.
- Davenport, Thomas H., *Process Innovation-Reengineering Work through Information Technology*. Boston: Ernst & Young, 1993.
- Davidow, William H., and Michael S. Malone. *The Virtual Corporation*. New York: HarperCollins Publishers, Inc. 1992.
- Deming, W. Edwards. *Out of the Crisis*. Cambridge, Mass.:MIT Center for Advanced Engineering Study, 1986.
- Dertovzos, Michael L., Richard K. Lester, and Robert M. Solow. *Made in America: Regaining the Productive Edge*. Cambridge, Mass.: MIT Press, 1989.
- Department of Defense(DoD) Directive 3222.3. *Department of Defense Electromagnetic Compatibility Program(EMCP)*. November 20, 1990.
- Department of Defense(DoD) Directive 3222.4. *Electronic Warfare and Command, Control, and Communications Countermeasures*. July 31, 1992.
- Department of Defense(DoD) Directive 4600.4. *Command, Control, and Communications Countermeasures*. August 27, 1979.
- Department of Defense(DoD) Directive 4630.5. *Compatibility, Interoperability, and Integration of Command, Control, Communications, and Intelligence(C3I) Systems*. November 18, 1992.
- Department of Defense(DoD) Directive 5000.1. *Defense Acquisition*. February 23, 1991.
- Department of Defense(DoD) Directive 5000.2. *Defense Acquisition Management Policies and Procedures*. February 23, 1991.
- Department of Defense(DoD) Directive 4650.1. *Management and Use of the Radio Frequency Spectrum*. June 24, 1987.
- Department of Defense(DoD) Directive 5100.35. *Military Communications Electronics Board*. May 6, 1985.
- Department of Defense(DoD) Directive 5160.57. *Electromagnetic Compatibility Analysis Center*. September 23, 1966.
- Drucker, Peter F. *The New Realities: In Government and Politics, in Economics and Business, in Society and World View*. New York: HarperCollins, 1989.
- Economic Report of the President*. Washington: GPO, February 1995.

Edmonds, Albert J., LTG, USAF, "C4I for the Warrior facilitates C2 Warfare," *Intercom*, February 1994, 3, 7.

Electromagnetic Spectrum Management Strategic Plan. OASD(C3I). Washington, February 1993.

Emerging Telecommunications Technology Act of 1991, 102d congress, 1st session(1991) and House Rule 531.

Executive Order 12046, "Relating to the Transfer of Telecommunications Functions," March 27, 1978, 3 CFR, 1978 Comp 158, reprinted in 47 U.S.C. 305 app. at 115(1989).

Ferriter, Edward C., "Which Way Joint Doctrine?," *Joint Force Quarterly*, Summer 1995, 118-119.

47 U.S.C. & 151 et seq. (1988 & Supp IV 1992).

47 U.S.C. && 901-904(Supp.V 1993).

Golden, James R. *Economics and National Strategy in the Information Age*. Westport: Praeger, 1994.

Gore, Al, "From Red Tape to Results: Creating a Government that Works Better and Costs Less," Accompanying Report of the National Performance Review, Office of the President of the Vice President, September 7, 1993.

Grier, Peter, "Information Warfare," *Air Force Magazine*, March 1995, 34-37.

Halberstam, David. *The Next Century*. New York: William Morrow, 1991.

Hammer, Michael, and James Champy. *Reengineering the Corporation-A Manifesto for Business Revolution*. New York: HarperCollins Publishers, Inc., 1993.

Hutcherson, Norman B, "Command and Control Warfare: Putting Another Tool in the War-Fighter's Data Base," Maxwell Air Force Base, AL: Air University Press, September 1994.

"Information Needs Surge Despite Defense Drawdown," *National Defense*, September, 1995, 22- 23.

"Interservice Training Review Organization Detailed Analysis Group: Recommendations for Communications and Information Technology Training Studies," Final report. Fort Gordon, GA:U.S. Army Signal Center & Fort Gordon, 11-12 August 1994.

Jefferies, Chris L., "Defense Decisioning in the Organizational Bureaucratic Context," in *American Defense Policy*, edited by John S. Endicott and Roy W. Stafford, Jr. Fourth Edition, Baltimore, MD: The John Hopkins University Press, 1977, 227-239.

Joint Doctrine Capstone and Keystone Primer. Washington: 25 May 1995.

Joint Pub 0-2. *Unified Action Armed Forces*. Washington: 24 February 1995.

Joint Pub 1. *Joint Warfare of the Armed Forces of the United States*. Washington: 10 January 1995.

Joint Pub 2-0. *Joint Doctrine for Intelligence Support to Operations*. Washington: 5 May 1995.

Joint Pub 3-0. *Doctrine for Joint Operations*. Washington: 1 February 1995.

Joint Pub 5-0. *Doctrine for Planning Joint Operations*. Washington: 13 April 1995.

Joint Pub 6-0. *Doctrine for Command, Control, Communications, and Computer(C4) Systems Support to Joint Operations*. Washington: 30 May 1995.

Johnson, Stuart E., and Martin C. Libicki. *Dominant Battlespace Knowledge: The Winning Edge*. Washington: National Defense University Press, October 1995.

Kennedy, Paul. *Preparing for the Twenty-first Century*. New York: Random House, 1993.

Keyworth II, G.A., "Let's Say Goodbye to the FCC," *Washington Post*, May 16, 1995, D1-D6.

Kotz, Nick. *Wild Blue Yonder*. New York: Pantheon Books, 1988, 1-11.

Krepinevich, Andrew F., "Cavalry to Computer: The Pattern of Military Revolutions," *The National Interest*, Fall 1994, 30-42.

Libicki, Martin C. *What Is Information Warfare*. Washington: National Defense University Press, August 1995.

Mann, Steven R., "Chaos Theory and Strategic Thought," *Parameters*, Autumn 1992, 54-68.

Markey, Edward J., "Universal Access: Good Social Policy and Good Economic Policy, Then and Now," *Washington Post*, May 16, 1995, D6-D7.

Mazarr, Michael J. *The Revolution in Military Affairs: A Framework for Defense Planners*. Carlisle Barracks, PA: U.S. Army War College Strategic Studies Institute, June 10, 1994.

McCann, Vonya, "Information Superhighway To Circle the Globe," *Washington Post*, May 16, 1995, D8.

Memorandum from the Chairman of the Military Communications-Electronics Board to the Assistant Secretary of Defense (Command, Control, Communications and Intelligence), "Establishment of a Joint Spectrum Center". December 15, 1993.

Memorandum from the Joint Staff Director for Command, Control, Communications, and Computer Systems(J6) to the Assistant Secretary of Defense(Command, Control, Communications and Intelligence), "Joint Spectrum Center". August 9, 1995.

Memorandum from the Assistant Secretary of Defense(Command, Control, Communications and Intelligence) to the Secretaries of the Military Departments, Chairman of the Joint Chiefs of Staff, and Directors of the Defense Agencies, " Creation of a Joint Spectrum Center." February 25, 1994.

Memorandum from the Assistant Secretary of Defense(Command, Control, Communications and Intelligence) to the Director, Command, Control, Communications and Computer Systems, "Joint Spectrum Center," August 24, 1995.

Memorandum from the Assistant Secretary of Defense(Command, Control, Communications and Intelligence) to the Secretaries of the Military Departments, Chairman of the Joint Chiefs of Staff, and Directors of the Defense Agencies, " Creation of a Joint Spectrum Center." October 17, 1994. (Modified February 25,1994 memo).

Memorandum from the Office of the Inspector General to the Deputy Secretary of Defense, *et.al.*, "Audit Report on DoD's Evaluation and Analysis of Electronic Combat," Project No. 2AB-0024, March, 1993.

Memorandum from the Three Star Service Senior Communicators to the Assistant Secretary of Defense(Command, Control, Communications and Intelligence), "Joint Spectrum Center." April 28, 1995.

Metz, Steven, and James Klevit. *Strategy and the Revolution in Military Affairs: From Theory to Policy*. Strategic Studies Institute, U.S. Army War College, Carlisle Barracks, PA, June 27, 1995.

Mills, Mike. "Telecommunications Bill Passed," *Washington Post*, February 2,1996, A1, A15.

NAVTELCOMINST 2400.1, *Management and Use of the Radio Frequency Spectrum within the Department of the Navy*, 19 October 1989.

"Navy Fleet Information Warfare Command Center to Open in Two Weeks," *Inside the Navy*, September 18, 1995, 5-8.

Neilson, Robert E., and Charles B. Giasson. "Information-The Ultimate Weapon," *Signal*, April, 1994, 545-549.

Office of Management and Budget Circular No. A-11, "Preparation and Submission of Budget Estimates," June 1989, Section 12.4(e).

Omnibus Budget and Reconciliation Act, Title VI, & 6001(a)(3), Public Law No.103-66, 107 Statute 379, August 10, 1993(codified at 47 U.S.C. & 921 et seq. , Supp.V 1993.

- Owens, William A., ADM. USN, "The Emerging Systems of Systems," *Naval Institute Proceedings*, May 1995, 35-39.
- Perry, William J. *Annual Report to the President and the Congress*. February 1995. Washington: GPO, February 1995.
- Peters, Tom. *Thriving On Chaos*. New York: Knopf, 1994.
- Program Budget Decision 082. "Defense Investigative Service(DIS) and the Joint Spectrum Center(JSC)." December 5, 1994.
- Samuelson, Robert J., "The Quiet Giveaway," *Newsweek*, May 13, 1991, 52.
- Saunders, Renee, "Open Season on Telecommunications Agencies," *Communications*, July, 1995, 11.
- Schneider, Robert, and Gregory Frick, "A National Security Strategy for the Information Age," unpublished paper for the National Defense University School of Information Warfare and Strategy, October 4, 1995.
- Shalikashvili, John M. *National Military Strategy of the United States of America 1995*. Washington: GPO, 1995.
- Smith, Hedrick. *Rethinking America*. New York: Random House, 1995.
- "Spectrum Management in a Joint Environment," Air Land Sea Application Center. Langley Air Force Base, VA: January 1994.
- Stein, George J., "Information Warfare," *Airpower Journal*, Spring 1995, 30-39.
- Stevens, Tim, "A Tidal Wave of Technology," *Industry Week*, December 20, 1993, 17-21.
- Strategic Assessment 1995: U.S. Security Challenges in Transition*. Institute for National Strategic Studies. Washington: GPO, November 1994.
- Sun Tzu, *The Art of War*. London: Oxford University Press, 1970.
- Teresko, John, "Tripping Down the Information Superhighway," *Industry Week*, August 2, 1993, 33-40.
- Toffler, Alvin, and Heidi Toffler. *War and Anti-War: Survival at the Dawn of the 21st Century*. Boston: Little, Brown and Company, 1993.
- U.S. Commission on Roles and Missions of the Armed Forces, "Directions for Defense: Report of the Commission on Roles and Missions of the Armed Forces," Washington: GPO, May 24, 1995.

- U.S. Department of Commerce. *Manual of Regulation and Procedures for Federal Radio Frequency Management*. Washington: NTIA Publication, June 1994 edition.
- U.S. Department of Commerce. *Federal Spectrum Management: A Guide to the NTIA Process*. Washington: NTIA Special Publication 91-25(Rev 1), August 1992.
- U.S. Department of Commerce. *U.S. National Spectrum Requirements: Projections And Trends*. Washington: NTIA Special Publication 94-31, March 1995.
- U.S. Department of Commerce. *U.S. Spectrum Management Policy: Agenda for the Future*. Washington: NTIA Special Publication 91-23, February 1991.
- U.S. Department of Commerce. *Preliminary Spectrum Reallocation Final Report*. Washington: NTIA Special Publication 94-27, February 1994.
- U.S. Department of Commerce. *Spectrum Reallocation Final Report*. Washington: NTIA Special Publication 95-32, February 1995.
- U.S. Department of Commerce. *Putting the Information Infrastructure to Work: Report of the Information Infrastructure Task Force Committee on Applications and Technology*. Washington: NIST Special Publication 857, May 1994.
- U.S. Department of Commerce. *The Global Information Infrastructure: Agenda for Cooperation. Report of the Information Infrastructure Task Force Committee*. Washington: February, 1995.
- U.S. President(Clinton). *A National Security Strategy of Engagement and Enlargement*. The White House: February 1995.
- Webster's Ninth New Collegiate Dictionary*. Springfield, Mass.: Merriam- Webster, Inc., 1984.